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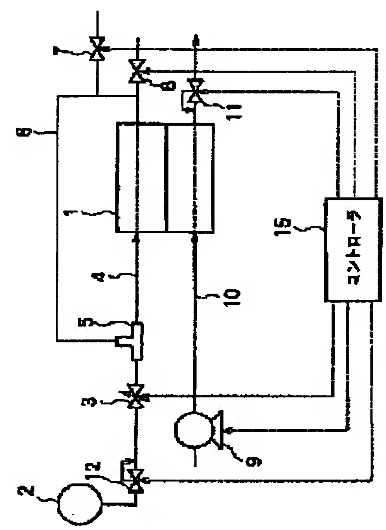
(54) FUEL CELL SYSTEM

(57) Abstract

PROBLEM TO BE SOLVED: To provide a fuel cell system capable of surely starting in a short time even after being left unattended over a long time.

SOLUTION: A hydrogen substitution valve 8 using a closing valve is a fuel gas discharge means or replacing a hydrogen line with hydrogen, and has an opening area set larger than that of a purge valve 7. When starting, the substitution valve 8 is opened for replacing the gases in a fuel electrode and in a fuel pipe with hydrogen to supply hydrogen to the system from a variable throttle valve 3 at a nearly constant flow rate, and thereby hydrogen substitution (fuel gas substitution) for replacing the inside of a hydrogen line comprising a hydrogen pipe 4, the inside of the fuel electrode and a hydrogen return pipe 6 with newly supplied hydrogen is carried out.



CLAIMS

[Claim(s)]
[Claim 1] In the fuel cell system equipped with the body of a fuel cell by which the fuel electrode and the oxidizer pole were opposite-**(ed) on both sides of the electrolyte membrane, and a fuel gas supply means to supply fuel gas to the body of a fuel cell through a fuel gas supply path Having a fuel gas discharge means to discharge to the exterior the exhaust fuel gas discharged from the body of a fuel cell, and supplying fuel gas to a fuel electrode by the flow rate of abbreviation regularity from said fuel gas supply means at the time of starting of a fuel cell system The fuel cell system characterized by performing the fuel gas permutation which permutes said fuel gas supply path and the interior of a fuel electrode with fuel gas by discharging exhaust fuel gas from said fuel gas discharge means.
[Claim 2] The fuel cell system according to claim 1 characterized by having a purge means to discharge temporarily outside a part of exhaust fuel gas [at least] discharged from the body of a fuel cell, and said fuel gas discharge means having a bigger opening area than said purge means during fuel cell operation.
[Claim 3] The fuel cell system according to claim 1 or 2 characterized by equipping said fuel gas supply path with a variable-aperture valve, and seting the opening of said variable-aperture valve constant at the time of said fuel gas permutation.
[Claim 4] The ejector arranged between the variable-aperture valve which controls the flow rate of said fuel gas supply path, and said variable-aperture valve and body of a fuel cell, Fuel circulation piping which returns the exhaust fuel gas discharged from the body of a fuel cell to inhalation opening of said ejector, The fuel cell system according to claim 1 or 2 characterized by adjusting whenever [said variable-aperture valve-opening] so that it may have a pressure detection means to detect the fuel gas pressure of said ejector upstream and the fuel gas pressure of said ejector upstream may serve as a predetermined value at the time of said fuel gas permutation.
[Claim 5] The fuel cell system according to claim 4 characterized by having a pressure detection means to detect the fuel gas pressure of said ejector lower stream of a river, and deciding the predetermined value of the fuel gas pressure of said ejector upstream according to the fuel gas pressure of an ejector lower stream of a river at the time of said fuel gas permutation.
[Claim 6] A fuel cell system given in any 1 term of claim 1 characterized by making it end if predetermined time progress of said fuel gas permutation is carried out thru/or claim 5.
[Claim 7] A fuel cell system given in any 1 term of claim 1 characterized by terminating said fuel gas permutation based on the fuel gas concentration which was equipped with a fuel gas concentration detection means to detect the fuel gas concentration in the fuel electrode of the body of a fuel cell, or a fuel gas path, and this fuel gas concentration detection means detected thru/or claim 5.
[Claim 8] A fuel cell system given in any 1 term of claim 1 characterized by terminating said fuel gas permutation based on the pressure which was equipped with a pressure detection means to detect the fuel gas pressure of said fuel gas discharge means upstream, and this pressure detection means detected thru/or claim 5.
[Claim 9] The fuel cell system according to claim 8 characterized by terminating said fuel gas permutation after predetermined time progress from from when said pressure detection means detects a predetermined pressure drop.

[Claim 10] In the fuel cell system equipped with the body of a fuel cell by which the fuel electrode and the oxidizer pole were opposite-**(ed) on both sides of the electrolyte membrane, and a fuel gas supply means to supply fuel gas to the body of a fuel cell through a fuel gas supply path A fuel gas discharge means to discharge to the exterior the exhaust fuel gas discharged from the body of a fuel cell, A pressure detection means to detect the fuel gas pressure of this fuel gas discharge means upstream, By discharging exhaust fuel gas from said fuel gas discharge means, supplying fuel gas to a fuel electrode from said fuel gas supply means at the time of starting of a preparation and a fuel cell system The fuel cell system characterized by terminating said fuel gas permutation based on the pressure which performed the fuel gas permutation which permutes said fuel gas supply path and the interior of a fuel electrode of the body of a fuel cell with fuel gas, and said pressure detection means detected.
[Claim 11] The fuel cell system according to claim 10 characterized by terminating said fuel gas permutation after predetermined time progress from from when the pressure which said pressure detection means detected falls to a predetermined value.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a fuel cell system, and relates to the fuel cell system which can shorten warm-up time especially.
[0002]
[Description of the Prior Art] For example, there are some which were indicated by patent No. 2735396 as the starting approach of a fuel cell system. When a fuel and air are supplied, the output voltage of a fuel cell is supervised and this output voltage value exceeds an electrical-potential-difference permission lower limit, he is trying to take out a power load in this conventional example at the time of starting.
[0003]
[Problem(s) to be Solved by the Invention] However, even if it is in the condition in which the output voltage of a fuel cell rose, if a power load is taken out, a problem may arise. For example, the case where it is left without carrying out long duration operation of the fuel cell system is considered. Since the fuel electrode of a fuel cell and the fuel gas in a fuel line are diffused gradually, or react with the oxygen in air and are gradually lost within a fuel cell out of a system in the state of neglect, the inside of a fuel electrode and a fuel line will be in air or the condition that nitrogen was full.
[0004] Here, in order to start a fuel cell system, shortly after it supplies a fuel electrode, and supplying fuel gas and air to an air pole, respectively, even if the air in a fuel electrode or a fuel path is not enough replaced with fuel gas, the output voltage of a fuel cell starts. However, when the load was taken out immediately here, since the fuel gas concentration in a fuel path or a fuel electrode was inadequate, the rapid voltage drop occurred and there was a trouble that it was stabilized and a load could not be taken out.
[0005] It is made in order that this invention may solve the trouble of the above conventional techniques, and even if the purpose is after long duration neglect, it is offering the fuel cell system which can be started certainly in a short time.
[0006]
[Means for Solving the Problem] It makes it a summary to permute a fuel gas supply path and the interior of a fuel electrode with fuel gas by discharging exhaust fuel gas from a fuel gas discharge means, it equipping a fuel cell system with a fuel gas discharge means to discharge to the exterior the exhaust fuel gas discharged from the body of a fuel cell, and supplying fuel gas to a fuel electrode from a fuel gas supply means at the time of starting of a fuel cell system, in order that this invention may attain the above-mentioned purpose.
[0007]
[Effect of the Invention] According to this invention, the fuel electrode of a fuel gas path and a fuel cell is certainly permuted by fuel gas at the time of starting of a fuel cell system, and even if it is after long duration neglect, it is effective in the ability to start certainly in a short time.
[0008]
[Embodiment of the Invention] Next, the gestalt of operation of this invention is explained to a detail with reference to a drawing.
The [1st operation gestalt] Drawing 1 is a block diagram explaining the configuration of the 1st

operation gestalt of the fuel cell system concerning this invention. In this drawing, the fuel cell stack 1 which is a body of a fuel cell pinches with a separator the fuel cell structure which opposite-**(ed) the oxidizer pole and the fuel electrode on both sides of the solid-state polyelectrolyte film, and carries out the laminating of two or more these. Air is used as an oxidizer supplied to hydrogen and an oxidizer pole as fuel gas supplied to a fuel electrode.

[0009] The hydrogen gas of a hydrogen tank 2 (fuel gas supply means) is supplied to the fuel cell stack 1 through the variable-aperture valve 3. It is controlled by the controller 15 so that, as for the variable-aperture valve 3, the hydrogen supply pressure to the fuel cell stack 1 usually becomes proper at the time of operation.

[0010] In addition, a pressure regulator 12 is formed between a hydrogen tank 2 and the variable-aperture valve 3, and it is not concerned with the residual pressure of a hydrogen tank 2, but is controlling by this operation gestalt to supply the hydrogen gas of a constant pressure to the variable-aperture valve 3.

[0011] An ejector 5 is formed in the hydrogen piping 4 (fuel gas supply path) between the variable-aperture valve 3 and the fuel cell stack 1. The surplus hydrogen which is exhaust fuel gas discharged from the fuel cell stack 1 is returned to inhalation opening of an ejector 5 through the hydrogen return line 6 which is fuel circulation piping, and the reaction effectiveness of the fuel cell stack 1 is usually gathered by circulating hydrogen by the ejector 5 at the time of operation.

[0012] The purge valve 7 using a closing motion valve is usually a purge means for purging hydrogen Rhine temporarily, when the hydrogen path for example, in a fuel cell stack is blockaded with water at the time of operation.

[0013] The hydrogen permutation bulb 8 using a closing motion valve is a fuel gas discharge means for permuting hydrogen Rhine from hydrogen at the time of starting, and is set as a bigger opening area than a purge valve 7. A compressor 9 compresses air, and supplies it to the inlet port of the oxidizer pole of the fuel cell stack 1, and the pneumatic pressure of an oxidizer pole is adjusted by the air pressure adjustment valve 11 prepared in the outlet of an oxidizer pole. Supply of the air to the fuel cell stack 1 and control of pneumatic pressure are performed when a controller 15 controls a compressor 9 and the air pressure adjustment valve 11.

[0014] Next, the outline of the activation procedure of the fuel cell system by the above-mentioned configuration is explained based on the flow chart of drawing 2 . First, if starting actuation is started at step (a step is hereafter abbreviated to S) 11, directions of permutation initiation of a fuel electrode and the gas in a fuel line will come out. Subsequently, hydrogen is continuously opened the hydrogen permutation bulb 8 and supplied [S12] to a system by S13 with abbreviation constant flow (for example, 100L / part extent), and the hydrogen permutation (fuel gas permutation) which replaces the inside of hydrogen Rhine which consists of the hydrogen piping 4, the interior of a fuel electrode, and a hydrogen return line 6 from the hydrogen supplied newly is performed.

[0015] With this operation gestalt, in order to supply hydrogen with constant flow, it was made to make regularity opening of the variable-aperture valve 3 at the time of a hydrogen permutation. With [the pressure ratio of the upstream/lower stream of a river of the variable-aperture valve 3] 1.9 [or more], the variable-aperture valve 3 will be in a choke condition. Therefore, if the set pressure of a pressure regulator 12 is made sufficiently high, it is not influenced by the bottom fluid pressure of the variable-aperture valve 3, but a flow rate will become fixed if opening is fixed.

[0016] It judges that hydrogen Rhine was enough permuted with predetermined time (for example, about 10 seconds) having passed by S14, termination 3, i.e., a variable-aperture valve, is closed for a hydrogen permutation, and supply of hydrogen is stopped. Said predetermined time finds experimentally the necessary minimum time amount which can perform permutation sufficient by the above-mentioned permutation flow rate beforehand, adds whenever [a certain amount of allowances] to this necessary minimum time amount, and permutes only that time amount.

[0017] The hydrogen permutation bulb 8 is closed by S15, in S16, based on operation, air and hydrogen are usually supplied, and power load ejection is started.

[0018] In addition, with this operation gestalt, the hydrogen permutation bulb 8 with a larger opening area than a purge valve 7 was formed independently [a purge valve 7]. In order that a purge valve 7 may not worsen specific fuel consumption, he wants to make it into a necessary minimum opening area, but when the reason for having formed the hydrogen permutation bulb 8 separately [the

conventional purge valve 7] does so, it is a hydrogen permutation at the time of starting, and when it is going to pass a big flow rate, it is because a pressure loss becomes large.
[0019] Of course, one closing motion valve may be used as a hydrogen [a purge valve 7-cum-] permutation bulb. In this case, if bulb opening area is enlarged, the purge flow rate when usually purging during operation will increase superfluously, and fuel consumption will increase.
[0020] If bulb opening area is made small and it is going to enlarge a hydrogen permutation flow rate contrary to this at the time of starting, there is a possibility of giving a damage to a fuel cell stack, a hydrogen permutation flow rate must be made small, required permutation time amount will become [the pressure applied to a fuel cell stack by the pressure loss of a bulb will become high,] long, and warm-up time will be prolonged.
[0021] However, by considering as one bulb, low-cost-izing is possible, and it is the balance of specific fuel consumption, warm-up time, and cost, and should choose whether a bulb is set to one, or it is made two.
[0022] In addition, although the system made to circulate through hydrogen by the ejector above has been explained, it cannot be overemphasized that this invention can be applied also in the system made to circulate through hydrogen using the hydrogen circulating pump by external power and the system which is not made to circulate through hydrogen.
[0023] As explained above, there is effectiveness that according to this operation gestalt positive starting becomes possible in a short time even if it is after prolonged neglect, in order to perform certainly required sufficient hydrogen permutation for a fuel gas supply path and the interior of a fuel electrode, at the time of starting.
[0024] Since it can judge with having permuted enough with predetermined time having passed by considering the supply flow rate of fuel gas as abbreviation regularity especially, the above-mentioned effectiveness can be acquired by easy control.
[0025] Moreover, since the supply flow rate of fuel gas serves as abbreviation regularity by seting the opening of a variable-aperture valve constant, a control configuration will become easier.
[0026] The [2nd operation gestalt] Drawing 3 is a block diagram explaining the configuration of the 2nd operation gestalt of the fuel cell system concerning this invention. The differences with this operation gestalt and the 1st operation gestalt are having formed the pressure sensor 13 which detects ejector appliance inlet pressure between the variable-aperture valve 3 and the ejector 5, and having formed the pressure sensor 14 for detecting the hydrogen pressure supplied to the fuel cell stack 1. Since other configurations are the same as that of drawing 1 , the explanation which gives the same sign to the same component and overlaps is omitted.
[0027] With this operation gestalt, in the hydrogen permutation at the time of starting, the controller 15 adjusted the opening of the variable-aperture valve 3 so that the ejector appliance inlet pressure which a pressure sensor 13 detects might be fixed (for example, about 0.5 bars).
[0028] Since passage is extracted by the nozzle of the entrance side, if hydrogen is passed, a pressure loss will generate an ejector 5. Therefore, if the ejector appliance inlet pressure at the time of a hydrogen permutation is set as the value in which it is high and an ejector 5 carries out a choke at the time of a permutation, the supply hydrogen flow rate at the time of a hydrogen permutation will be made to regularity by making upper fluid pressure of an ejector 5 regularity.
[0029] Next, the flow chart of drawing 4 explains the hydrogen replacement procedure in this operation gestalt. First, if directions of permutation initiation come out by S21, hydrogen will be supplied, adjusting the opening of the variable-aperture valve 3 so that the appliance inlet pressure of the ejector 5 which opens the hydrogen permutation bulb 8 by S22, and the pressure sensor 13 detects by S23 may serve as a predetermined value. If hydrogen supply, i.e., actual permutation time amount, serves as predetermined time, the variable-aperture valve 3 is closed by S24, hydrogen supply will be ended, the hydrogen permutation bulb 8 will be closed by S25, and a series of permutation operations will be ended.
[0030] In addition, an ejector 5 may not change into a choke condition with the magnitude of the nozzle of an ejector 5, a hydrogen permutation flow rate, etc. at the time of a hydrogen permutation.
[0031] The magnitude of an ejector should usually be decided with the amount of hydrogen which is decided by the property of a fuel cell stack and through which you want to circulate by the ejector at the time of operation.

[0032] Moreover, the amount of hydrogen of a hydrogen permutation flow rate which will be discharged if many [too] increases, and since the combustor which burns discharge hydrogen and which is not illustrated is enlarged or fuel consumption gets worse, it cannot be made [many / extremely].
[0033] When a hydrogen permutation flow rate is made little setup using an ejector with a big nozzle area, it becomes impossible for example, to maintain an ejector in the state of a choke at the time of a permutation.
[0034] In such a case, as shown in drawing 5 , according to the appliance inlet pressure of the fuel cell stack 1, the ejector appliance inlet pressure from which a hydrogen demand flow rate serves as predetermined constant value is beforehand stored in a controller 15, and if the variable-aperture valve 3 is adjusted so that it may become the pressure, the same effectiveness can completely be acquired.
[0035] Positive starting was attained, even if it was after prolonged neglect like the 1st operation gestalt according to this operation gestalt in order to perform sufficient hydrogen permutation certainly required at the time of starting as explained above.
[0036] Especially, using the existing ejector, using the property in which an ejector carries out a choke, the supply flow rate of fuel gas can be considered as abbreviation regularity simply and certainly by adjusting whenever [variable-aperture valve-opening] so that the fuel gas pressure of the ejector upstream may serve as a predetermined value.
[0037] Moreover, since the fuel gas pressure of the ejector upstream is decided according to the fuel gas pressure of an ejector lower stream of a river, even if it changes the fuel gas pressure of an ejector lower stream of a river, the supply flow rate of fuel gas can be considered as abbreviation regularity simply and certainly.
[0038] The [3rd operation gestalt] The configuration of this operation gestalt is the same as that of the 2nd operation gestalt shown in drawing 3 . Transition of the fuel cell stack appliance inlet pressure at the time of a hydrogen permutation is shown in drawing 6 . Hydrogen Rhine of a fuel cell system is completely filled with air before starting, and the continuous line of drawing 6 is the case where a permutation takes time amount most.
[0039] If a pressure declines and hydrogen Rhine is completely filled with hydrogen as fuel cell stack appliance inlet pressure will once rise and a permutation will progress, if hydrogen supply is begun, a pressure will be fixed (for example, 3kPa(s)) (P0).
[0040] A pressure when molecular weight of air is large and it is permuted with constant flow to hydrogen, in case this passes a hydrogen permutation bulb is because it is large to hydrogen. That is, in permutation flow rate regularity, it can judge how many air remain in hydrogen Rhine by the bottom fluid pressure of an ejector.
[0041] With this operation gestalt, fuel cell stack appliance inlet pressure was used as bottom fluid pressure of an ejector.
[0042] Moreover, the broken line of this drawing is an example when hydrogen remains in hydrogen Rhine of a fuel cell system before starting. When it is the broken line with which hydrogen remains to permuting for t 1 hour, it turns out by t2 (t2<t1) that it is good in the case of the continuous line with which hydrogen Rhine is filled with air.
[0043] With this operation gestalt, this property was used, and when the appliance inlet pressure of a fuel cell stack was less than the predetermined value (P0) at the time of a hydrogen permutation, the permutation was ended. That is, the role of a means by which the pressure sensor 13 which detects ejector appliance inlet pressure detects fuel gas concentration is also regarded as the hydrogen concentration of a fuel gas path having become beyond a predetermined value (more than minimum concentration required for a generation of electrical energy) in the fuel electrode about the appliance inlet pressure of a fuel cell stack having been less than the predetermined value (P0) previously.
[0044] Next, the hydrogen permutation at the time of starting in this operation gestalt is explained based on the flow chart of drawing 7 .
[0045] If directions of permutation initiation come out by S31 first, hydrogen will be supplied adjusting the opening of the variable-aperture valve 3 so that the ejector appliance inlet pressure which opens the hydrogen permutation bulb 8 by S32, and the pressure sensor 13 detects by S33 may serve as a predetermined value. The variable-aperture valve 3 is closed by S35, in below a

predetermined value, hydrogen supply is ended, it closes the hydrogen permutation bulb 8 by S36, and ends a series of permutations so that the appliance inlet pressure of the fuel cell stack 1 which the pressure sensor 14 detects by S34 may judge below in a predetermined value and hydrogen supply may be continued as it is in beyond a predetermined value.

[0046] It became possible to consider as necessary minimum permutation time amount by carrying out like this according to the amount of hydrogen survival in hydrogen Rhine of a fuel cell system (concentration), and positive starting was attained, having held down to min the amount of hydrogen lost by the permutation, and shortening warm-up time.

[0047] Moreover, the amount of hydrogen survival in hydrogen Rhine (concentration) can be distinguished now with the gas pressure value of the hydrogen permutation bulb 8 upstream which is a fuel gas discharge means, and there is also no need of using the sensor only for hydrogen concentration.

[0048] Moreover, it becomes easy to judge that the pressure of the fuel gas discharge means upstream became below the predetermined value with the increment in the fuel gas in a fuel electrode or a fuel gas path by what the supply flow rate of fuel gas is considered as abbreviation regularity for. the case where this invention is not applied -- the supply flow rate of fuel gas -- abbreviation -- a thing or distinguishing with fluctuation of a fuel gas supply flow rate become that it will not follow on the increment in the fuel gas in a fuel electrode or a fuel gas path even if it becomes less fixed and the pressure of the fuel gas discharge means upstream becomes below a predetermined value, and difficult, and control serves as uncertainty.

[0049] In addition, although the pressure sensor 14 which detects fuel cell stack appliance inlet pressure was used with this operation gestalt, it cannot be overemphasized that a fuel cell stack lower stream of a river is sufficient as it, for example as long as the location of a pressure sensor is a lower stream of a river from an ejector.

[0050] Although it is ideal to use hydrogen permutation bulb appliance inlet pressure originally, if the pressure loss of a fuel cell stack is small enough, fuel cell stack appliance inlet pressure can be substituted as mentioned above.

[0051] In addition, although it was made to set a permutation flow rate constant by making ejector appliance inlet pressure regularity, whenever [variable-aperture valve-opening] is fixed and a permutation flow rate may be made to become fixed.

[0052] The [4th operation gestalt] The configuration of this operation gestalt is the same as that of the 2nd operation gestalt shown in drawing 3 . When it is made a setup of the hydrogen permutation flow rate which the fuel cell stack inlet pressure at the time of a permutation goes up up to a maximum of 40 kPa when the inside of hydrogen Rhine is filled with air, and a hydrogen permutation bulb with the above-mentioned 3rd operation gestalt, in the condition after permuting enough, a pressure serves as about 3 kPa(s). In order to bear such maximum-pressure 40kPa and to detect the low voltage force with a sufficient precision, an expensive pressure sensor is needed.

[0053] When the precision of a pressure sensor is low, although it does not fully permute, a permutation termination judging is carried out or the fault [a permutation] no longer ending is predicted by the sensor indicated-value top, without a pressure falling to P0.

[0054] So, with this operation gestalt, even after it set the judgment pressure to P1 [a little higher than P0 of drawing 6] (for example, 6kPa(s)), instead fuel cell stack appliance inlet pressure became less than [P1], predetermined time (for example, about 3 seconds) hydrogen supply was continued.

[0055] Drawing 8 is a flow chart explaining hydrogen permutation actuation of this operation gestalt. The difference with the 3rd operation gestalt of drawing 7 is S45, and after a stack inlet pressure becomes below a predetermined value (P1), it is continuing supplying predetermined time hydrogen further and continuing a permutation.

[0056] It became possible to carry out, to be stabilized and to start certainly required sufficient permutation, it having been cheap and using a pressure sensor with a low precision by carrying out like this.

[0057] In addition, although it was made to set a permutation flow rate constant by making ejector appliance inlet pressure regularity, whenever [variable-aperture valve-opening] is fixed and a permutation flow rate may be made to become fixed.

[Translation done.]

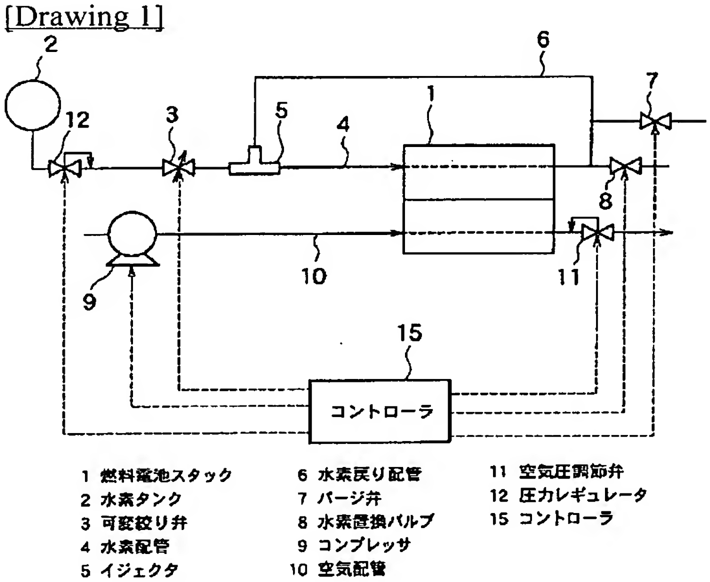
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a block diagram explaining the configuration of the 1st operation gestalt of the fuel cell system concerning this invention.
[Drawing 2] It is a flow chart explaining actuation of the 1st operation gestalt.
[Drawing 3] It is a block diagram explaining the configuration of the 2nd operation gestalt of the fuel cell system concerning this invention.
[Drawing 4] It is a flow chart explaining actuation of the 2nd operation gestalt.
[Drawing 5] It is drawing showing the ejector inlet pressure from which the hydrogen flow rate to a fuel cell stack inlet pressure serves as a predetermined value.
[Drawing 6] It is drawing showing time amount change of the fuel cell stack inlet pressure at the time of the hydrogen permutation in the 3rd operation gestalt.
[Drawing 7] It is a flow chart explaining actuation of the 3rd operation gestalt.
[Drawing 8] It is a flow chart explaining actuation of the 4th operation gestalt.
[Description of Notations]
1 -- Fuel cell stack
2 -- Hydrogen tank
3 -- Variable-aperture valve
4 -- Hydrogen piping
5 -- Ejector
6 -- Hydrogen return line
7 -- Purge valve
8 -- Hydrogen permutation bulb
9 -- Compressor
10 -- Pneumatic piping
11 -- Air pressure adjustment valve
12 -- Pressure regulator
13 -- Pressure sensor
14 -- Pressure sensor
15 -- Controller

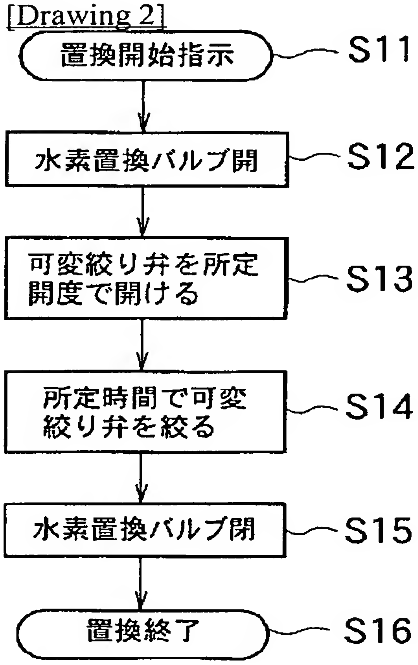
[Translation done.]

DRAWINGS

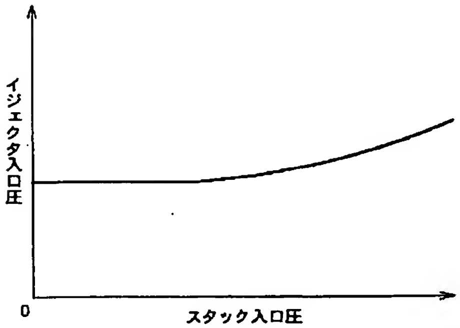
[Drawing 1]



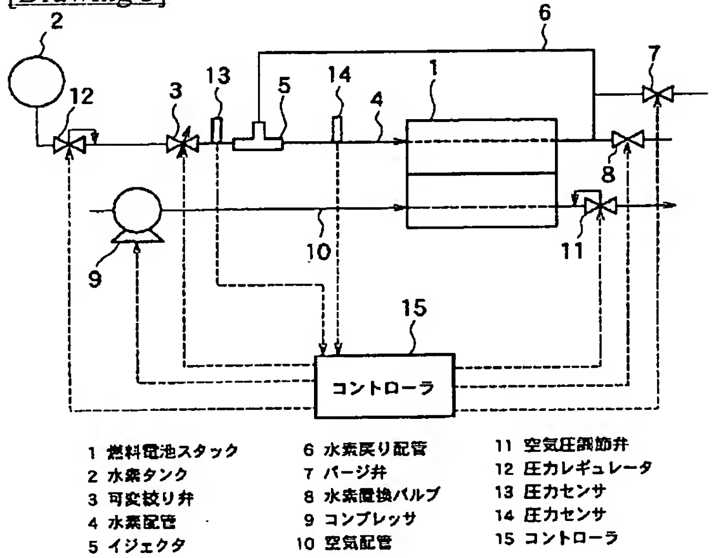
[Drawing 2]



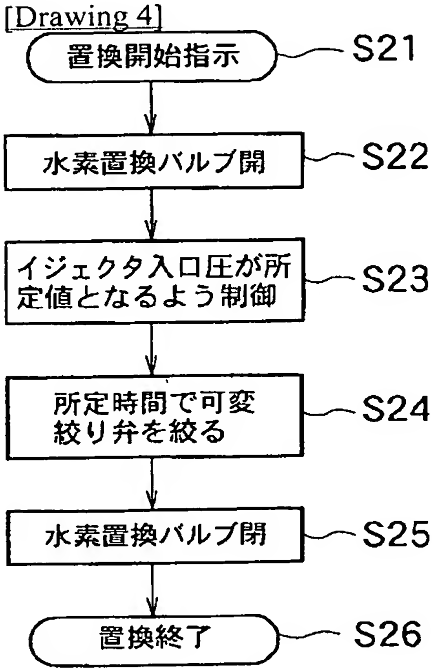
[Drawing 5]



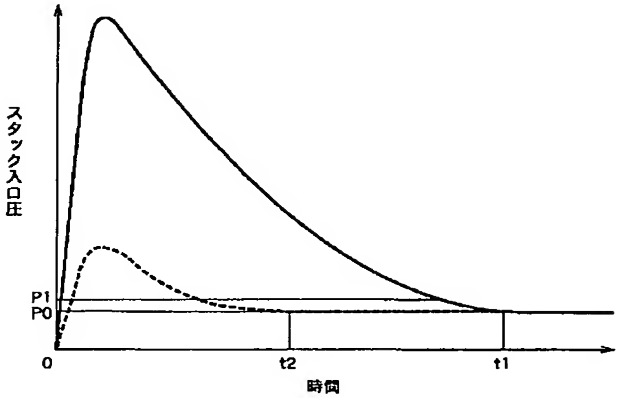
[Drawing 3]



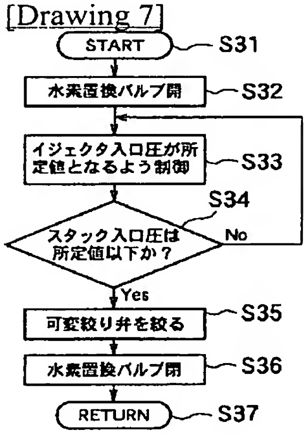
[Drawing 4]



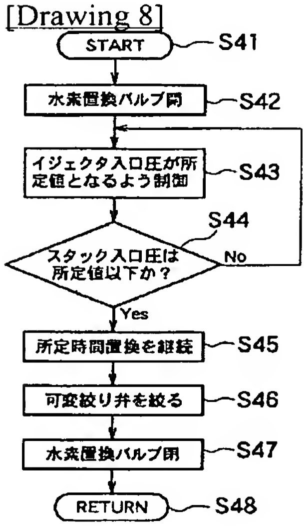
[Drawing 6]



[Drawing 7]



[Drawing 8]



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